Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Unit Test – SPH3U Grade 11 Physics – Waves and Sound

There are 4 parts to this test. Answer all questions. Read each question carefully and answer exactly what the question asks. You will have the entire 75 minute class to finish the test if you need it. Once you are done turn your paper over and read quietly. If you are not sure of an answer move on to the next question and come back to that one later.

(Total out of 70 marks).

**Part 1: Multiple Choice** (20 marks)

Circle the letter corresponding to the **most** correct answer.

1. If sound travels at 340 m/s why does it take 2 seconds to hear the echo off a wall 680 m away?

a. It takes 2 seconds because echoes travel twice as fast as sound

b. Echoes travel at 1/2 the speed of sound

c. It takes sound 1 second to get there and 1 second to get back

d. It only takes 1 second to hear the echo

2. How is the Doppler Effect used to measure the velocity of a sound source (e.g. police car with the siren on)?

a. The Doppler Effect can only be used to measure position not velocity

b. The frequency of the received sound from the source changes as the distance to the source changes

c. The frequency of the received sound from the source changes as the velocity of the source changes

d. The time it takes the sound to reflect off the object is used to calculate the velocity of the source

3. Why doesn't sound travel through a vacuum?

a. Vacuums are too cold to allow sound waves to travel through them

b. Sound is a waveform operating in matter, and there is no matter in a vacuum

c. Vacuums absorb most of the sound

d. Explosions in space can be heard therefore sound does travel in space

4. Which statement is **FALSE** regarding the speed of sound in air if the humidity increases?

a. The time needed to travel a given distance decreases

b. The speed of sound decreases slightly on a humid day

c. The speed of sound increases slightly on a humid day

d. ‘a’ and ‘c’ are true

5. What is the BEST way to ensure that two (2) tuning forks are in tune with each other?

a. Compare the Hz rating on the fork

b. Weigh them on a digital scale to determine their exact weights

c. Strike them simultaneously and listen for any beat frequency

d. Compare each with the correct piano key

6. What would the beat frequency be if you added tones of 880 Hz and 882 Hz?

a. There would be no beat frequency

b. 2 Hz

c. 881 Hz

d. 1762 Hz

7. What happens when you add two waves that are completely out of phase but equal in amplitude?

a. Constructive interference occurs and the amplitude doubles

b. The amplitude is reduced to ¼ the original

c. The waves become scattered noise

d. They cancel out each other

8. How is frequency related to period?

a. Period and frequency refer to the same thing

b. Period = 1/frequency

c. Frequency = amplitude \* period

d. Wavelength = speed / frequency

9. The frequency of middle “A” on the piano is 440 Hz. What is the frequency of the “A” that is 2 octaves above that?

a. 220 Hz

b. 880 Hz

c. 1760 Hz

d. 1320 Hz

10. Why is it that you can observe waves moving in to shore but an inflatable mattress on the water does not move into shore with the waves?

a. The waves are being blown by the wind but the mattress is not affected because it is too low.

b. The water molecules inside the wave are moving in a circular pattern so that there is no net motion to propel objects forward

c. The molecules inside the wave move up and down only so the mattress will not move forward.

d. The slope of the waves is too steep to allow the mattress to take advantage of the waves’ forward motion.

**Part 2: Short Answer**

1. In movies people sometimes put their ears on the train tracks to check for trains. Would this technique warn you of an approaching train before you could hear the train whistle? (Explain your answer) **(4 marks)**

2. When determining the speed of sound using a glass column, a column of water, and a tuning fork, we used 2 adjacent resonant points and found the difference in air column length between the 2 points. Why did we do this instead of just using 1 resonant point? **(6 marks)**

**Part 3: Problems**

1. A large earthquake hits the Pacific Ocean near Japan. The time of the earthquake is 5:00 AM local time on Thursday August 15 in Los Angeles. The authorities estimate that the wavelength of the resulting tsunami will be approximately 400 km; however the frequency of the wave is expected to be only 2 Hz. The site of the earthquake is 8000km from Los Angeles. There is a sand castle building contest scheduled for 2:00-4:00 PM local time on Thursday, August 15 at a beach near Los Angeles. Should they cancel the contest because of the coming tsunami or will they finish before the wave arrives? **(7 marks)**

2. The length of the “E” string on a guitar is 65 cm and it produces a sound with a frequency of 82.4 Hz. At what speed does the wave travel along the “E” string?

**(5 marks)**

3. The CNR trains are supposed to approach crossings at 60 km/hr and begin sounding their train whistles. The whistle produces a loud sound at a frequency of 220 Hz. The owners of the train suspect that the train engineers are exceeding the speed as they approach crossings. To test their assumptions the owners set up a receiver to measure the frequency of the approaching train whistle and the temperature of the air. As the train #5 approaches, the observed frequency of the train whistle is 235 Hz at the stationary receiver and the air temperature is 15 oC. Should the engineer be punished for speeding or rewarded for obeying the rules and why? **(8 marks)**

{The formula for the speed of sound is V = (331.4 + 0.6 \* T), T is air temp. in oC}

**Part 4: Essay/Diagram Questions**

1. Using diagrams explain the theory behind the fact that the length of tube used in your closed-end panpipes was determined by the formula:

Length of pipe = ¼ \* wavelength **(8 marks)**

2. Two (2) pebbles are dropped in a quiet lake. Draw the resulting wave patterns developed using concentric circles around the 2 points of impact. Assume that the lines are the crests of the waves and the spaces between the lines are the troughs. Indicate three (3) locations where constructive interference is occurring and three (3) locations where destructive interference is occurring. Label your areas “C” for constructive and “D” for destructive. **(6 marks)**

3. Give 1 example of constructive interference and 1 example of destructive interference of waves in action and briefly explain how the phenomenon is used in society. **(6 marks)**

Unit Test – SPH3U Grade 11 Physics – Waves and Sound

**Answer Guide**

**Part 1: Multiple Choice** (K, U)

Circle the letter corresponding to the **most** correct answer. 2 marks for each correct answer – total of 20 marks.

1. If sound travels at 340 m/s why does it take 2 seconds to hear the echo off a wall 680 m away?

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c. The molecules inside the wave move up and down only so the mattress will not move forward.

d. The slope of the waves is too steep to allow the mattress to take advantage of the waves’ forward motion.

**Part 3: Short Answer**

1. In movies people sometimes put their ears on the train tracks to check for trains. Would this technique warn you of an approaching train before you could hear the train whistle? (Explain your answer) (C, A) 4 marks

**A**. *This technique really does work because sound travels faster in steel (5,960 m/s) than in air (340 m/s) so that the sound of the train travelling through the steel rails will reach your ear before the sound from the horn going through air. The steel rails also provide a channel for the sound to travel in and the waves therefore dissipate less quickly while the air allows the wave to dissipate in all directions and they become weaker faster. So the sounds waves arriving through the rails arrive first and with a strong signal.*

2. When determining the speed of sound using a glass column, a column of water, and a tuning fork, we used 2 adjacent resonant points and found the difference in air column length between the 2 points. Why did we do this instead of just using 1 resonant point? (C, T/I) 6 marks

**A**. 3 marks →*The actual length of the wave inside the tube is a little bit longer than ¼ the length of the air column because of the fact that the antinode at the end of the tube lies slightly beyond the tube itself. 2 marks→By subtracting the 2 adjacent points we are left with a distance that equals exactly ½ the length of the wavelength that was set up in the tube. 1 mark →This means we do not have to worry about how far the sound wave extends beyond the tube.*

**Part 2: Problems** (K/U, C, A)

1. Background: A large earthquake hits the Pacific Ocean near Japan. The time of the earthquake is 5:00 AM local time on Thursday August 15 in Los Angeles. The authorities estimate that the wavelength of the resulting tsunami will be approximately 400 km; however the frequency of the wave is expected to be only 2 Hz. The site of the earthquake is 8000km from Los Angeles. There is a sand castle building contest scheduled for 2:00-4:00 PM local time on Thursday August 15 at a beach near Los Angeles. Should they cancel the contest because of the coming tsunami or will they finish before the wave arrives? (7 marks)

**A.** *400 km/hr = 400 \* 1000 / 3600 = 111 m/s* 1 mark

*V = f \* λ* 1 marks

*V = 2Hz \* 111 m/s*

*V = 222 m/s*

*V = 222 \* 3600 / 1000 = 800 km/hr* 1 mark

*The wave is travelling at 800km/hr toward Los Angeles* 1 mark

*8000 km/ 800 km/hr = 10 hrs to reach Los Angeles* 1 mark

*The wave will reach the Los Angeles beach at 5am + 10 hours = 3pm local time.*

*The contest should be cancelled because of the coming tsunami wave.* 2 marks

2. The length of the “E” string on a guitar is 65 cm and it produces a sound with a frequency of 82.4 Hz. At what speed does the wave travel along the “E” string? (5 marks)

*For a vibrating string:*

*λ = 2 \* the length of the string* 2 marks

*λ = 2 \* 0.65 = 1.3 m*

*V= f \* λ* 1 mark

*V = 82.4 Hz \* 1.3 m*

*V = 107.1 m/s* 1 mark

*The wave travels along the string at 107.1 m/s.* 1 mark

3. The CNR trains are supposed to approach crossings at less than 60 km/hr and begin sounding their train whistles. The whistle produces a loud sound at a frequency of 220 Hz. The owners of the train suspect that the train engineers are exceeding the speed as they approach crossings. To test their assumptions the owners set up a receiver to measure the frequency of the approaching train whistle and the temperature of the air. As the train #5 approaches, the observed frequency of the train whistle is 230 Hz at the stationary receiver and the air temperature is 15 oC. Should the engineer be punished for speeding or rewarded for obeying the rules and why? (8 marks)

{The formula for the speed of sound in air as is V = (331.4 + 0.6 \* T), T = oC}

**A.** *Speed of sound in air = 331.4 + 0.6 \* 15*  1 mark

*= 340.4 m/s*

*For a source that is moving towards a stationary receiver the formula used is:*

*Fobs = Fs \* [V÷ (V - Vs)]* 2 marks

*Solving for Vs:*

*Fobs/Fs = V / (V-Vs)*

*V – Vs = V / (Fobs/Fs)*

*Vs = V – [V/(Fobs/Fs)]* 2 marks

*Vs = 340.4m/s – [340.4m/s / (230Hz/220Hz)]* 1 mark

*Vs = 340.7m/s – 325.6m/s*

*Vs = 15.1 m/s*

*Vs = 54.4 km/hr.* 1 mark

*The engineer should be rewarded for going 54.4 km/hr which is under the 60 km/hr speed limit.* 1 mark

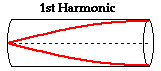
**Part 3: Essay/Diagram Questions** (K/ U, C, A)

1. Using diagrams explain the theory behind the fact that the length of tube used in your **closed-end** panpipes was determined by the formula:

*Length of pipe = ¼ \* wavelength* (use the first harmonic in your explanation). (8 marks)

**A.** 2 marks – including diagram and labelling

Node Antinode

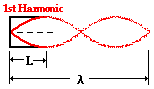


First Harmonic in a closed tube.

3 marks for the explanation

The distance between adjacent antinodes on a standing wave pattern is equivalent to one-half of a wavelength. Since nodes always lie midway in between the antinodes, the distance between an antinode and a node must be equivalent to one-fourth of a wavelength. Thus, the length of the air column is equal to one-fourth of the wavelength for the first harmonic as shown below.

3 marks for this type of diagram properly labelled



Length of closed pipe vs. total wavelength

Therefore the length of pipe = ¼ \* wavelength of the tube.

2. Two (2) pebbles are dropped in a quiet lake. Draw the resulting wave patterns developed using concentric circles around the 2 points of impact. Assume that the lines are the crests of the waves and the spaces between the lines are the troughs. Indicate three (3) locations where constructive interference is occurring and three (3) locations where destructive interference is occurring. Label your areas “C” for constructive and “D” for destructive. 6 marks – (for correct location of C’s and D’s). (C, K/U, T/I)

D

C

C C

D

D

3. Give 1 example of constructive interference and 1 example of destructive interference of waves in action and briefly explain how the phenomenon is used in society. 6 marks – (1 for each example and 2 for the explanation) (C, A)

*Examples:*

* *Musical Instruments playing in tune - constructive*
* *Concert halls built to amplify sounds - constructive*
* *Sound control systems in factories producing out of phase sounds to muffle machinery noise – destructive*
* *Masses and extra beams added to bridges to change their natural resonant frequencies so that they will exhibit destructive interference with the vibrations set up by winds – destructive.*